THE

AGRICULTURAL BULLETIN

OF THE

FEDERATED MALAY STATES.

No. 10.] JULY, 1917. [Vol. V.

RUBBER PREPARATION.

Demonstration of Experimental Vulcanizing Plant, etc.

A VISIT was paid on the 26th April to the experimental paper-making factory and visitors were shown the plant employed for the complete manufacture of paper from various raw products and the methods of manufacture were explained briefly. The fibre-making machinery for the manufacture of clean fibre from sisal, agave, etc., which is housed in the same building was also inspected. A complete unit of plant on a commercial scale for the extraction of oil from oil seeds of all kind, including copra and Para rubber seed, which is also erected in the same building, was shown and explained.

Visitors then inspected the experimental retort and condenser for the distillation of crude acetic or pyroligneous acid from various local woods, including rubber wood, which was being distilled at the time.

Subsequently a detailed inspection of the experimental vulcanizing machinery and apparatus employed for the testing of vulcanized rubber was made. A demonstration of the methods employed was given, including the mixing, calendering and vulcanizing of the rubber and the subsequent testing of the vulcanized product. Messrs. B. J. Eaton (Agricultural Chemist) and F. W. F. Day (Assistant Agricultural Chemist) explained the processes to visitors and the former gave a brief account of the nature of the variability of plantation Para rubber and showed numerous specimens of the raw rubber, which behaved differently during vulcanization owing to the method of preparation. Numerous questions were asked by members of the audience and replied to. A very keen interest was taken in the demonstration, the plant and methods of testing being quite new to many visitors who had not visited the experimental vulcanizing factory before and had not seen a rubber vulcanizing factory.

Finally visitors were shown the chemical laboratory and took a keen interest in the chemical apparatus and methods employed for the chemical examination of rubber, soils, oils, and other agricultural products.

RUBBER MANUFACTURE AND FACTORY METHODS.

By F. G. Souter,

(Manager, Sandycroft Estate, Perak, F.M.S.)

It is not proposed in this paper to deal with the subject matter in a general way, and an attempt will be made to confine it to routine work in a factory, as being better calculated to promote discussion and be of practical help to any who require it.

The main object to be attained is the highest possible price for an estate's out-turn in every grade of rubber, and as each grade requires special treatment of its own, I will take them separately, and give the methods adopted for each, on the estate under my charge. No claim is put forward that these are incapable of improvement, but they are the product of many experiments, and consistently high rates obtained for the estate's output in Singapore and London, appear to show that, under existing conditions, the right lines have been chosen to work on, at least as far as this estate is concerned. There are necessarily the elements of variability in climatic conditions, systems of tapping, and types of machinery to be reckoned with, which preclude any idea of uniformity in factory work all over the Peninsula, but I will try to show how these variations can be met to give the best possible results.

It must be assumed that a factory is making its entire crop, including lower grades, and has a full equipment of machinery, sufficient space for coagulating, and adequate smoking and drying accommodation. These requirements are necessarily defined by the quantity of rubber dealt with, and in what form the first latex is turned out, but granted that we are prepared to make either smoked sheet or pale crêpe as occasion demands, to do justice to a crop of anything up to 200,000 lbs., a full plant of machinery would be :—a washer, macerating-roller, crêpeing-roller, smooth-finisher, and two hand or power sheeting-machines, with a 40 H.-P. engine to drive it. A smoke-house capable of holding 12,000 lbs. of rubber would be wanted, drying sheds with a capacity of 10,000 lbs. and a packing-room conveniently near. These buildings should be entirely apart from the factory, but access to them should be by a covered way, and transport of wet rubber from the factory made as easy as possible by trolleys on rails. The receiving-house for latex and coagulating-shed should also be, either a separate building close to the factory, or an adjunct of the latter with a partition to keep coolies other than factory hands away from the machinery. For estates with a much larger output, equipment would be on a larger scale though not necessarily proportionately. Many estates are now putting in a duplicate plant to make themselves safe against a break-down of any essential, and, for those in the happy position of being able to afford the cost, the measure is a very commendable one. With so many high class engineering firms specializing in rubber machinery a planter can get

any type or design of machine he wants, and any pattern of grooving cut on heavy rollers and sheet-making machines. The plant on this estate consists of a 50 B. H.-P. "Mirrlees-Diesel" engine with a 40 B. H.-P. "Crossley" engine in reserve, a "Universal" washer, three new type Shaw's heavy machines, two Shaw's hand or power sheeting-machines, and three old type Shaw's heavy machines. Approximately, 300,000 lbs. are treated in the course of a year and it will be seen that we are practically insured against a stoppage caused by a break-down to any one engine or machine.

The floor of each building should be of good clean cement and immediately under and near the rollers white tiles are an aid to cleanliness.

PREPARATION OF RIBBED SMOKED SHEET.

I take this grade first as it seems to have finally established itself as the most convenient form in which to turn out No. 1 latex, and is made on nearly every estate. It is not essential to have expensive machinery to deal with it, and small estates can make smoked sheet with the bulk of their crop without a heavy capital outlay. It thus justifies its position as first favourite with planters generally. It is also the most interesting grade to make, as so much depends on attention to detail, and neglect of any kind is very apparent in the finished article, though it may possibly pass unnoticed when the sheet leaves the marking-machine. Perfection is more difficult to attain in smoked sheet than in any form of crêpe. because nothing can be done to rectify any mistake at any time during the process of curing. You cannot tear out a piece of bark or grit from a sheet in the same way as in pale crêpe without ruining the appearance of the sheet; you cannot roll it smooth again once it has got torn in the rollers without leaving an ugly mark; you cannot get rid of bubbles once the coagulation has set; "rust" remains for good after the first day's drying, and no amount of scrubbing and washing will rid you of dust or ash which has got on to the sheet before it has a film of smoke over it.

These defects all have their value when the manufacturer's representative has a look at the rubber in the broker's show-room, and a penny a pound less than the best is a serious thing over a year's production from any estate. It is, roughly, $6,000 on a crop of 200,000 lbs. as much as the manager's salary for the year probably. Most of the well-found estates are now turning out smoked sheet of a high standard, but one has only to look at the range of prices quoted in the brokers' sale reports to see that some estates at least are not getting the best they can. I have been round show-rooms in Singapore with some of the leading American buyers, and they are very emphatic about their requirements in standard smoked sheet. It must be clean, strong, thoroughly smoked, uniform in appearance, and give the same results under vulcanization in the same time in

every shipment. The last is the most important of all from the manufacturer's point of view as it saves time and money in experimenting with each shipment, and if he can rely on an estate's output giving the same results regularly he will buy that rubber and pay full value for it. This serves to show that, having found the right methods in the factory, a manager is ill-advised to alter any part of his process, as any change may have a strong bearing on the results given by his rubber under tests and put the buyers off for some considerable time.

Straining of Latex.

The first important part of the making of smoked sheet is the straining of the latex. This should be done through fine gauze, 60 mesh, and two sieves should be used—one above the other. The reason for this is that if the sieve gets clogged the cooly in charge invariably rubs the gauze with a piece of rubber till the latex runs freely through, and fine sand and dirt get pushed through with the latex. The lower sieve catches anything of the kind, and no rubbing of the gauze should be allowed on the lower sieve. If this gets clogged it should be replaced by a clean sieve and used on top, the one formerly on top being removed and thoroughly washed to be used again. A sufficient number of spares should be at hand to change continuously.

Standardization.

I dilute with cup washings simultaneously with the straining of the latex, both going together through the two sieves. No water is put in the cups during tapping so that the latex is too rich in itself, and the cup-washings increase the output of sheet by about 2 per cent. without any harm being done, as dirt cannot pass through both sieves. There is probably one gallon of cup-washings to two gallons of pure latex in the mixture, and the out-turn on the total gallonage for the last two years has been $1\frac{1}{2}$ lbs. of dry rubber per gallon, variations from month to month being fractional, and dependant on weather conditions. Rain during collection upsets most calculations, and an attempt to preserve uniformity is made during coagulation. In normal weather I can rely on standard latex without the aid of a "Metrolac." Owing to the fact that I have contract tapping at varying rates I have to separate latex from trees over 10 years old from that from young trees. In pan coagulation $\frac{1}{4}$ of a gallon of water is put into each pan. If rain has fallen during collection this is dispensed with and instead of a gallon of latex and cup-washings being put into each pan the latexometer is brought into the picture and sufficient latex and cup-washings put in to equalize as nearly as possible a normal day's size of sheet. I deprecate the use of the "Metrolac" more than is necessary. It means nothing to the ordinary cooly, who, if he has been at the job long enough is a very good judge of the density of latex by

simpler methods, and it is only the incident of rain upsetting the normal state of things, and the varying rubber content of latex during the wintering months that call for a reading of the instrument. These methods are perhaps crude, but they are practical and suited to the intelligence of the factory cooly, and the results have been consistently good. Where tapping is done by coolies on daily wage entirely, bulking the whole of the estate's latex is of course the surest method of ensuring standardization.

Coagulation.

Having bulked our latex and cup-washings the next step is to add the acid necessary for coagulation. This is done before the latex is put out into pans and a stock solution is kept ready in air-tight jars. The solution is made up of 12 oz. acetic acid and ½ lb. sodium bisulphite to one gallon of water—one gallon of this being sufficient for 80 gallons of latex and cup washings. I have tried sulphuric acid on a small scale, but was not very successful with it, and did not continue experiments, the main reason being that we had buyers who relied on uniformity from the estate, and the change of acid might have upset previous vulcanization tests and lost the confidence of the buyers. Pans thoroughly washed are stacked at hand to receive the latex, each containing ¼ of a gallon of water and one gallon of latex is poured into each pan with as little delay as possible after the solution has been thoroughly stirred into the bulk. Skimming is done at once with a strip of tin almost as broad as the pan and the pans are placed on shelves in cupboards screened all round by a drop-curtain of turkey-red cloth. The pans used are 16″ × 10″ × 4″ and produce a dry sheet 25″ × 11″ in the case of latex from old trees and one slightly smaller from young rubber. Coagulation is usually finished by 12.30 p.m. and this allows for latex being brought in carts from outlying fields two miles from the factory. The pans are left untouched overnight. The reason for the added water not being put into the bulked latex is that I found bubbles resulted from bad fusion of water and latex owing to insufficient stirring by coolies when not watched, sheets from the same jar or tank varying considerably. The method used leaves nothing to chance and is therefore preferable. There is also economy in the number of jars or tanks required for containing the bulk of latex before it is put out into pans. In tank coagulation the solution of acid is put into the latex after it has settled in the tanks and before the partitions are placed in their slots. The majority of tanks I have seen do not give such good results as pans owing principally to the fact that the partition laths are not perfectly water tight and permit latex to ooze through from one division to another causing a ragged edge on each sheet which is difficult to get rid of. Most of them are also too big, without enough divisions to deal with the ever varying gallonage. When an estate has tapping done by

several different contractors, whose rubber has to be kept separate, the sub-division of a tank into small compartments is very necessary to ensure an even quantity and equal density of latex in each, every day.

I have been experimenting with a small tank made to contain 40 gallons and have had good results from it. It is light enough to go on a small trolley and be moved about by one cooly up to the receiving tank, and back, when filled, to the most convenient place for dealing with the coagulation. It is made of acid-proof concrete and is 30″ × 68″ × 9″ and makes 34 sheets. The only disadvantage is that the sheets turn out too narrow for economy in rolling, and I am having a deeper one made by the designers, Messrs. R. Young and Co., Penang, to remedy this. The small tanks on wheels seem to me to have many advantages over the large tank on a fixed base.

Kneading and Rolling.

When the coagulated sheet is taken out of the pans in the morning it is placed on a smooth heavy chengai board, and coolies tread it out till it is a firm mass, ready for the smooth roller. This saves rolling more than is necessary and, I believe, retains the strength in the finished sheet. Kneading by hand, or rolling out with a rolling pin, takes longer to get the sheet tough enough to go through a roller without tearing, unless the first rolling is done with the rollers very far apart, and several subsequent rolls are wanted. Coolies soon become experts at treading sheets out evenly, and reduce the thickness to the desired limit quicker than machines can, without tearing. The sheets then go once through a heavy smooth roller set at about $\frac{1}{16}$ of an inch, then through another, set at $\frac{1}{32}$ of an inch, and then through the marking roller set just hard up enough to miss grinding. The setting of the last two rollers is never altered, the adjusting keys being removed entirely so that the coolies in charge have no option in the matter. This ensures uniformity in thickness. The sheeting-machines are 18″ × 7″ and have speed revolutions at the rate of 11 per minute for the smooth roller and 9 per minute for the marking roller. The grooving on the latter are spirals, $\frac{1}{8}$ of an inch apart, to give a small diamond, and the estate name is lettered round the centre of one roller, the spirals stopping where the lettering begins, and there is a blank space without spirals on the other roller exactly opposite. The main points to be observed in rolling are that sheets must go through evenly without a pull in any direction, and the lettering must be kept equi-distant from the edges of the sheet. If the rollers are set evenly the sheets will go through correctly without any guidance, if started evenly.

Economy in time is effected by having the sheets almost as broad as the length of the rollers. It takes just as long for a sheet 30″ × 9″ to go through as for one 30″ × 15″, and the actual difference in

the weight of rubber between the two is considerable. There is no point in having rollers 18″ long unless you are to utilize as much of this as possible.

Washing and Dripping.

After rolling, each sheet is washed and soaked in tepid water to get rid of any protein which causes what is called "rust" in sheet. I have found that without this washing in warm water, sheets have a tendency to stretch "rusty" and it is consequently worth doing properly. After washing, sheets are dripped till all water has left them. They are hung on racks which are thoroughly washed each day, the racks being designed so that each tier hangs free from the drip of the one above it. The stands are in the shape of an inverted V with round laths across to hang the sheets over. Square timber laths are not good, as the sheets take any impression very easily at this stage, and unsightly lines across the sheet invariably result where square laths are used. The dripping racks should be in a sheltered position where no dust can be blown on the rubber. Rolling is usually finished by 11 a.m. and sheets are ready for the smoke-house by 2 p.m.

Smoking.

Sheets should be put into the smoke-house as soon as possible after the water has all dripped off, as they do not take in the smoke so well if too dry. The only reason for not putting them in immediately after rolling is that water would drip from wet sheets on to finished or partly finished sheets that happened to be directly underneath, and the introduction of too much moisture into the building would retard drying beyond reasonable limits. Racks should be perfectly round and wiped over carefully before sheet is hung on them, to avoid dust getting into the rubber which will not wash off if it adheres before the sheets are fairly dry, and will appear as a cloudy grey line across the finished sheet, where it has come into contact with the dusty surface. Sheets should be turned and moved so that a fresh part is over the racks every day for the first four days of smoking, to ensure every part of the sheet getting smoke through it. The size of a sheet when it goes into the smoke-house is about 30″ × 15″ and it comes out 25″ × 11″ so that contraction reduces the square measurement of a sheet by about 40 per cent. It is essential for good smoking that this should not take place too rapidly, and for this reason I believe in slow drying and smoking. Rapid drying closes the sheet against a thorough permeation of smoke and I give 19 to 20 days slow smoking before I consider the sheet is finished, the temperature being kept low and too much up-draft avoided. If a building is of corrugated iron the smoke gets through the joints in the roof quite fast enough, and there is no necessity to have funnels to improve the current. My smoke house is a 60 feet by 30 feet

building of corrugated iron, with 4 furnaces, 6 feet by 3 feet, on the ground-floor on trolleys, and two stories above for hanging. It is divided across the centre into two divisions, 30 feet by 30 feet, by a partition to facilitate cleaning up from time to time. The full capacity of the building is never required, and by having this partition the place can be kept clean without interruption of the work. The smoke house is opened up from 12 noon to 3 p.m. only, when the atmosphere is driest, so that the entrance of moisture is avoided as much as possible. If the roof has had the sun on it for half a day there is less chance of condensation of moisture inside, and creasote drip on to the sheets does not take place. The fires are kept going for the rest of the 24 hours, and only rubber trees cut up into short lengths are used. I have tried coconut husks, but have not derived any beneficial results from them. Rubber seeds give a thick smoke but there is too much oil in it, which is easily apparent on the sheets, and the use of either coconut husks or rubber seeds usually means extra expense which has not shown itself to be justifiable. The lower floor is 10 feet above the ground and is covered with mosquito-proof wire netting to prevent sparks and dust going up with the smoke. The netting has to be brushed from time to time to keep it open enough for smoke to get through, and has to be renewed every 18 months, approximately. The trolleys have a sheet of corrugated iron on stays, four feet above the furnace, to deflect direct heat and distribute smoke. During the three hours when the fires are out and the smoke house is open, finished sheets are taken down and the day's make put in, and sheets of the previous four days turned. It is a convenient time to do this as coolies from the coagulating room are available in addition to those in the drying-shed. To check weights and assist monthly adjustment of stocks, a tally is kept of the number of sheets put in and sheets taken out, and each day's rubber is ticketed with the date. Rubber in store can thus be checked after each consignment if necessary.

Final Washing.

Finished sheets are washed and dried before packing, scrubbed with a horse brush dipped in clean water and hung on racks, the same as those used for dripping, and sun-dried for about 20 minutes. There is always a certain amount of dust which can be got rid of in this way, and the appearance of the rubber is improved. The sheets must be taken in as soon as they are dry, as they would soon become tacky in a hot sun.

Packing.

Before packing, sheets are picked over and any faulty ones separated to be sold as No. 2 sheet. Absolute perfection in methods, of course, precludes any possibility of spoilt sheets, but in practice it will be found that there is always a small percentage that would have a bad effect on a consignment, and it is better to sell these for a lower

price, and get full value for the bulk of the out-turn. Out of, approximately, 200,000 lbs. of sheet sold in 1916 we had 672 lbs. or four cases, of faulty sheets which fetched $3 per pikul less than the best, so that the net loss from this cause was about $15, whereas, if they had been mixed with the good sheets there might readily have been a loss of $1 per pikul over the whole total sold, or approximately $1,500.

Without the aid of a press, 168 lbs. of sheet go into one case. It is a convenient quantity as it is 1½ cwts. and 40 cases give three tons. If sheets are made or cut into lengths to fit the cases a larger quantity, up to 200 lbs., can be squeezed in. It always seems to me that the expense of packing smoked sheet is so unnecessary, as properly cured smoked sheet is impervious to damp for a considerable time and it is reasonable to suppose that before long we shall be baling our smoked sheet like wool, and avoiding the expense of Momi and Venesta cases.

PREPARATION OF PALE CRÊPE.

The main points required in the grade are colour and texture, and the attainment of either presents no great difficulties if uniform treatment is accorded every day.

Coagulation.

The latex is usually coagulated in bulk and the addition of extra water is of no moment as air bubbles are impossible in crêpe. The strength of acid is the same for this grade as for smoked sheet, but double the quantity of sodium bisulphite is wanted unless the rubber is to be rolled the same day. If the sodium bisulphite solution is too weak, oxidation will set in to a certain extent during the night, and the colour of the out-turn will suffer. I use 1 lb. of sodium bisulphite to a gallon of water for 80 gallons of latex with the usual 12 oz. of acid for latex to be treated next morning.

Rolling.

Strip coagulation in tanks is more economical than mass coagulation as the strip will go easily through a macerator without being cut up, rollers can be set fairly close for the first roll, and once through the macerator brings the rubber to a stage where the crêper and smooth finisher can deal with it. The macerator and crêper should be hard chilled rollers with uneven speeds, the number of teeth in the cogs being 21 for the front roller and 18 for the back one. The smooth finisher should be of softer metal and speeds of 20 and 18. It will be found in practice that a smooth roller will not do such good work when new, as it will when it has been working some months.

After the rubber has been through the macerater once and twice through the crêper it is a question of what style of crêpe is to be turned out, as to how many rolls are necessary in the finisher.

Blanket crêpe has gone out of favour, and thin lace crêpe is now the fashionable form, and to get this of close texture at least four rolls in the smooth finisher are necessary. The first one is done with a single length of rubber as it comes from the crêper, and the result is a thin strip full of holes. This is divided into lengths and three to four lengths put through together, making another thin strip with still a few holes, but getting nearer the right texture. Two lengths of this then go through evenly knitted together, and a final roll of the resultant single length should be enough. The smooth finished rollers are hard up during all four rolls. During the finishing process any soiled or discoloured pieces should be torn off to go into a lower grade.

The finished crêpe is dripped till all water is off and removed to the drying shed to be hung after weighing. Fine crêpe should be ready for packing in six to seven days. It should be pure white when it goes into the drying shed and should not darken beyond a rich cream colour. The thinner the crêpe is made, the lighter will it show up in colour when finished, and if the sodium bisulphite has been properly mixed into the latex the colour will be even.

Lower Crêpe Grades.

For the treatment of lump and bark scrap, of course, no coagulant is wanted, but sodium bisulphite plays a large part in the resultant colour of these. The rolling required is the same as for pale crêpe, but the preliminary treatment consists of washing mainly. It is important to deal with lump immediately it comes in from the field as oxidation has started, which means discolouration eventually, and the further oxidation has gone the worse the discolouration becomes. Oxidized pieces should be picked out by hand, and the lump put into the washer with hot water playing on it. I do this for 10 minutes and the hot water checks oxidation. A final washing of 10 minutes is given with the water turned off above, and the outlet shut below, enough water being kept in to come up to within an inch of the top of the rollers. A solution of sodium bisulphite is added and gets thoroughly into the mass during the washing process. The rubber is then rolled out in the same way as pale crêpe and should be very nearly equal in colour and texture to the first latex grade.

Bark and tree-scrap are washed together as soon as possible after arrival at the factory, and are treated in the same way as the lump, except that 10 minutes' longer washing is required to get rid of all dirt before the sodium bisulphite solution is added.

Folding and Packing.

The lengths of crêpe are taken down when dry and folded to fit the cases. A rather ingenious folding rack has been in use on Sandycroft Estate for a number of years. It consists of a frame

as long as the length of the case, and the lengths of crêpe are flicked over from side to side with round sticks—three on each side—two being used by the cooly for turning over, the others for keeping the crêpe in place. The sticks are pulled out in turn from underneath and used for flicking over the crêpe into place. When the frame is full the rubber is lifted out and pressed and retains its shape.

One hundred and twenty-five pounds go into each case without the use of a press. Any discoloured or stained lengths are removed to be made up again with an inferior grade before folding.

General.

It has been impossible in the limited time to deal fully with many essential parts of factory work, and without practical demonstration it is difficult to convey ideas, but I hope that this paper will be of help to some of those attending this Conference. Most of it is routine well known to most managers, but routine, particularly in the case of smoked sheet, is a dull and dangerous business unless constant attention is paid to every detail, and this, I consider, to be the only way to ensure the maximum price for an estate's production.

When a penny a pound on a yield of 360 lbs. per acre means £1 10*s*. per acre, extra profit, it is surely worth doing everything possible to get it.

THE PREPARATION OF PLANTATION PARA RUBBER WITH SPECIAL REFERENCE TO FUTURE CONSIDERATIONS.

By B. J. Eaton, F.I.C., F.C.S.

(*Agricultural Chemist, F.M.S.*)

IT is proposed in this paper to submit very briefly the results of the researches on raw rubber manufacture which have been conducted for the past $2\frac{1}{2}$ years at the Agricultural Department by the writer and his assistants and to consider in what way these results are likely to affect the future methods of preparation of the raw product, having in view both the highest quality of rubber which can be prepared and the manufacturers' requirements, as far as we have been able to obtain information in this respect.

As a starting point two axioms are propounded, with which I think every planter and manufacturer is now in entire agreement.

They are (1) The highest grade of wild rubber, *viz.*, Fine Hard Para, which is the premier raw rubber among wild rubbers, so called, on the market, is very uniform. (2) Plantation Para rubber from the cultivated Hevea is very variable. Arising out of both of these axioms we have now to consider: (*a*) In what respect is plantation Para rubber variable and how can this variability be remedied? (*b*) What are the causes of the variability in the case of the plantation product and what the reason of the uniformity of the product from the uncultivated tree?

I do not propose to enter into any details as to the researches which have enabled us to elucidate to a considerable extent these important problems, since much has already been published by the writer and his collaborators and since confirmed by other independent workers and in a month or two a special illustrated bulletin will be published giving the details of these researches to date. It is only necessary here to summarize the results obtained and, if further information is required on any special point, this may be probably obtained during the discussion of the paper.

Speaking historically, the remarks expressed by Mr. Williams, Works Superintendent of the North British Rubber Company, one of the leading and most advanced of our British rubber manufacturing firms, especially in the organization of scientific research, will form a suitable text on which to hang this discourse. These remarks which were made at the 4th International Rubber and Allied Trades Congress held in London in July, 1914, were as follows:

"My experience is that quite apart from all questions of strength, the question of the vulcanizing properties of plantation rubber is the greatest trouble the manufacturer has to face. Without efficient control, faulty vulcanization undoubtedly will be responsible for loss of time and money. These troubles, in factories where scientific control is not thoroughly organized, may be sufficient to condemn the use of this grade (that is plantation rubber, B. J. E.) entirely."

Since that date we have travelled far in our knowledge of the vagaries of this wonderful substance and one can say it, with a certain amount of pride, without being egotistical, that the Agricultural Department of the Federated Malay States has had the honour and good fortune of contributing the most important and fundamental researches on the problem.

The above remarks by Mr. Williams constitute the first intimation from the manufacturer of the nature of the variability of plantation rubber. These remarks were confirmed at the same Congress by Dr. Schidrowitz in a paper entitled "Variability" in which figures for numerous cases of such variability were published. Independently, later in 1914, our early researches led to the same conclusions; since which we have been able to discover the cause or causes of the variability and many of the contributing factors in connection with estate factory practice which have an influence on variability.

It can therefore in the first place be enunciated that the principal defect of the plantation product is its variable behaviour during vulcanization, or to put it in the technical terms used by the rubber manufacturer, variability in rate of cure or speed of vulcanization.

The remedy, *i.e.*, the method of obtaining uniformity in this respect, can only be attained after a realization of the cause, and the great aim of scientific research is to connect cause and effect in the world of nature. It may however be argued logically, assuming that variability is due chiefly or entirely to methods of preparation rather than to intrinsic differences in the latex on different estates or from different areas or districts, that uniform methods of preparation will ensure uniformity of product, but even so, we are at much greater advantage if we possess a knowledge of the cause, since it may then be essential only to adopt uniform methods in one or two respects. Secondly a knowledge of the cause of variability will enable us possibly to prepare an improved type of the raw product, having realized that our existing methods are entirely empirical and like "Topsy" have merely "grown."

Fortunately a knowledge of the cause of variability deduced from our researches, enables us to state that variable methods of preparation are chiefly, if not entirely responsible for variability of

the product, and this being so, we are more easily able to apply a remedy which consists in uniformity of method of preparation. Further the information derived from the elucidation of the cause of variability has enabled us to realize the second problem, *viz.*, the preparation of an improved type of raw rubber and it is essentially with this problem that I propose to deal.

Returning once more to the cause of variability, we have found that variability in rate of cure of the raw product is brought about by two factors: (1) the amount of an accelerator or catalyst produced in the raw rubber from the nitrogenous constituents of the latex by allowing the coagulum to mature for about six days before machining, and (2) the amount of some accelerating substance in the latex which is retained in the rubber by some process of preparation in which all the serum is retained.

The first of these substances, which has the greatest influence, especially in small quantities, we have found to be some decomposition product of the nitrogenous constituents. The second substance exists originally in the latex and is removed almost entirely when the fresh coagulum is converted shortly after coagulation to thin crêpe.

In dealing with the first of these factors, I propose only to summarize the factors which will influence the amount of such accelerator in the rubber. They are as follows:

(1) Amount of moisture in the prepared rubber;
(2) Amount of serum retained;
(3) Rate of drying;
(4) Thickness of coagulum before and after machining;
(5) Presence of antiseptics, *e.g.*, formalin, sodium sulphite and sodium bisulphite;
(6) Influence of different coagulants;
(7) Excess of coagulants, especially of certain coagulants;
(8) Influence of smoking;
(9) Influence of artificial methods of drying;
(10) Action of various chemicals on the finished rubber in retarding or accelerating rate of cure;
(11) Concentration of latex;
(12) Action of water as a solvent.

In dealing with the second accelerating factor the factors which influence the amount present are:

(1) Concentration of latex;
(2) Effect of water as a solvent on the finished rubber.

Whether other factors, such as the nature of the coagulant, or an excess of coagulant, antiseptics and other chemicals or smoking, have an effect on rapidly curing rubber, the rapidity of cure of which is due to some constituent of the latex normally

removed in the serum by the machining of fresh coagulum has not yet been ascertained, but is probable. In support of this we have the fact that Fine Hard Para which is comparatively slow curing, contains all the serum constituents and should be rapidly curing, but the vulcanization is retarded by the smoking process.

Dealing briefly with the factors involved in the variability of the first type of rubber in which the vulcanization is accelerated by the amount of some protein degradation product formed during the maturing of the coagulum by natural biological processes, the following factors accelerate rate of cure:

(1) High moisture content up to a certain limit;
(2) Large amount of serum;
(3) Thickness of coagulum up to a certain limit, which affects the rate of drying;
(4) Slow drying;
(5) Concentration of latex;
(6) Action of certain chemicals, especially the alkalis, soda and potash and their carbonates.

The following factors retard the rate of vulcanization:

(1) Low moisture content in the prepared coagulum;
(2) Removal of serum;
(3) Rapid drying;
(4) Thinness of coagulum which produces rapid drying and is also responsible for the removal of serum by machining;
(5) Presence of antiseptics, especially formalin, also boracic acid and tannic acid;
(6) Certain coagulants, *e.g.*, the mineral acids especially hydrochloric, sulphuric and hydrofluoric acids and certain salts especially the alums;
(7) Excess of coagulant—the effect of excess of weak organic acids, such as acetic, formic, citric, tartaric and oxalic is not very marked, while excess of the mineral acids has a marked retarding effect;
(8) Smoking;
(9) Artificial methods of drying—not very great in the case of thin crêpe, which is the only type of rubber subjected to artificial methods of drying;
(10) Dilution of latex with water;
(11) Action of water as a solvent.

With regard to the second factor responsible for variability in rate of cure the influence of various factors in retarding the rate of cure has not yet been investigated, but it is probable that smoking, mineral acid coagulants and alum and other antiseptics and chemicals will retard vulcanization.

The Uniformity of Fine Hard Para.

In my opinion the sole reason for the uniformity of Fine Hard Para is the law of averages. Each ball of Fine Hard Para probably takes from one to two months to prepare and thus any daily variation of the latex in concentration, etc., or any variation in the temperature or other conditions of the smoking process employed, are averaged. This indicates at once a method for rendering plantation rubber more uniform in bulk, *viz.*, the mixing together in each case, of rubber prepared on different dates.

Having summarized the causes of variability in plantation Para rubber and shown the principal factors which have an influence on the problem and stated the probable reason for the uniformity of Fine Hard Para, it can easily be seen what remedies should be adopted to secure uniform results. It is obvious that the problem is not excessively difficult on any one estate for one type of rubber, but that considerable difficulties arise in the endeavour to make all estates carry out a similar practice.

In considering the problem of variability we must at once realize that uniformity can only strictly apply to one type of rubber. Thus thin pale crêpe is intrinsically distinct from smoked or plain sheet and as long as there is a market demand for this grade, which will probably be always, since this type of rubber has created its own market for specific purposes for which no rubber of darker colour could be employed, it is impossible for estates to make one uniform product, since thin pale crêpe, from its mode of preparation will almost certainly always have a different rate of cure to smoked sheet. It might be suggested that this type of rubber be made as the sole first grade. The answer to this is that thin pale crêpe is almost always inferior to smoked or plain sheet in tensile properties and hence should not be used for articles in which strength rather than colour is a desideratum.

It is thus evident that for present demands we must prepare at least three and probably four grades of plantation rubber, that is either two first grade and one second grade or two first grade and two second grades. The probability is that four grades is the minimum, since it does not seem desirable from our researches to combine all lower grades. The best solution is probably the preparation of pale crêpe and one other first grade and the preparation of two lower grades as follows: No. 1 lower grade crêpe to consist of lump, skimmings and picked scrap, and No. 2 lower grade crêpe of bark shavings plus earth scrap.

It is not proposed here, however, to deal with lower grades but with first grades only, although in one respect, the question of "lump" rubber or cup and bucket coagulations, is of interest, as will be seen later.

The problem therefore with which we have to deal in connection with the preparation of first grades, is whether we are going to be content to produce pale crêpe and smoked sheet as carried on at present or to endeavour to substitute another and an improved type of rubber in place of smoked sheet and it is this problem primarily with which I propose to deal briefly, leaving the subject open for discussion, after bringing forward the salient facts in support of a new method of preparation.

It would probably be preferable to state at once that the proposed method of manufacture is that which we have styled "slab" rubber, in lieu of sheet.

Our researches have shown that whereas smoked sheet cures in about $2\frac{1}{2}$ to $2\frac{3}{4}$ hours under the conditions employed, "slab" rubber cures in about $1\frac{1}{4}$ hours or less than half the time. Apart from this, "slab" rubber is about 20 to 25 per cent. superior in tensile properties to crêpe and generally superior to smoked sheet. The advantages to the rubber manufacturer of this type of rubber are therefore obvious. Whether a manufacturer would be prepared to pay a premium for such rubber however remains to be seen and for the present it is taken for granted that such rubber would merely fetch the ordinary top market prices obtained for smoked sheet. We, therefore, have to consider its preparation entirely from the producer's point of view (assuming of course that it is not going to fetch a lower price on the market, as it probably would do if judged by appearance only). What are the advantages we must ask ourselves of any alteration of existing methods. Some planters may be very conservative in this respect and prefer a *laissez-faire* policy, but I venture to suggest that, especially at this time, we have no more right to adopt such a policy in our commerce and industry than we have in the conduct of our military affairs and I therefore assume that all planters are alive to the necessity of a change if it can be shown that such a change will produce an improved product.

We have now to consider the possible forms in which such a type of rubber can be prepared, taking note of the advantages and disadvantages of each method of preparation.

There are only three possible forms in which such rubber could be prepared for the market, *viz.* (1) virgin "slab" containing about 20 per cent. of moisture, (2) in the form of crêpe, (3) in the form of dry block.

Of these forms the most suitable when everything is taken into consideration, is the first. The only disadvantage of shipping virgin "slab" is that extra freight has to be paid on about 20 per cent. of water.

The pre-war freight on rubber was about $\frac{1}{2}d.$ or say 2 cents per lb., while the present rates are about $1d.$ or say 4 cents per lb.

If rubber containing 20 per cent. or at a maximum, say, 25 per cent. of water is shipped the actual amount of dry rubber sent for 2 cents at pre-war rates would be 80 or 75 per cent., respectively, that is to say, each pound of actual rubber will cost $2\frac{1}{2}$ cents or $2\frac{2}{3}$ cents at pre-war rates and 5 cents or $5\frac{1}{3}$ cents at present rates of freight. This represents an extra cost on freight of $\frac{1}{2}$ to $\frac{2}{3}$ cent at pre-war rates and 1 to $1\frac{1}{3}$ cents at present rates.

This extra cost has now to be compared from an economic point of view with the cost of preparing, say, smoked sheet in estate factories and this cost is represented when compared with "slab," by the actual cost of machining, since acetic acid or some other coagulant has to be used in the case of both "slab" and sheet.

The lowest factory costs for present first grades is probably about 1.5 cents per lb. which includes oil for engines and acetic acid, but does not allow for capital cost and depreciation of machinery and factory. In the preparation of "slab" rubber, apart from the machinery required to treat 20 to 30 per cent. of the crop which is represented by lower grades, all machinery and consequently a large factory is eliminated.

Leaving aside, however, the depreciation on factory and machinery, the cost of preparation of first grades is probably not lower than the above figure and in the preparation of virgin "slab" rubber the saving effected in cost of preparation will at least compensate for the extra freight even at present rates, while in most cases and at pre-war freights the saving in cost of preparation will probably be from 1 to 2 cents per pound on many estates.

The above figures have demonstrated that virgin "slab" is cheaper to prepare, requiring little care, apart from cleanliness, and that the saving on cost of preparation more than compensates for the extra freight charges on moisture.

Two other disadvantages may be mentioned, *viz.*, difficulty of fixing duty owing to a possible variable moisture content, and secondly the introduction of a new type of rubber may cause confusion among manufacturers. The first of these would be capable of adjustment in a short time and presents no greater difficulty than does Fine Hard Para while the second is not worth taking into consideration, since the manufacturer would soon realize the value of this type of rubber.

With regard to the shipping of "slab" rubber in the form of crêpe, there is no advantage to the producer, in fact possibly a slight disadvantage in that the coagulum after maturing for six days is very tough and therefore more difficult to machine. The advantages lie entirely with the manufacturer who is obtaining a better type of rubber, which is clean and dry, and probably may not, if properly packed, require rewashing.

One disadvantage which has been suggested is the difficulty of distinguishing such crêpe from many specimens of ordinary slow curing crêpe, except from first latex pale crêpe. This is easily surmounted, however, by labelling boxes, as is done at present for different grades and styling the rubber "slab" crêpe or some other fancy name. As a disadvantage it is not worth the consideration of either scientific or practical men, to use a distinction to which I object.

The third method, *viz.*, shipping in the form of dry block, presents one or two advantages, especially from the producer's point of view. In the preparation of dry block, the rubber has to be crêped thin, wormed on a special cutting machine, vacuum or hot air dried in this form and then pressed into blocks. Assuming we are leaving the coagulum for seven days, crêpeing can be carried out on the 8th day and the rubber prepared ready for shipping on the 9th day. A great saving in factory space is thus effected and also in packing space. It is recommended that the blocks be made about $1\frac{1}{2}$ to 2 inches thick. Rubber prepared in this manner has been examined in our laboratories nearly two years ago and found to give excellent results.

There is, of course, no improvement of quality in such block, the question being entirely one of economics.

The disadvantages, of course, of preparing the rubber in this form are very similar to those in the case of preparing and shipping as thin crêpe, except that drying space and packing space is saved.

I trust that the facts stated above will, especially at the close of the present war, when manufacturers are able to return to more normal conditions and to carry out experiments, stimulate further interest on the part both of the producer and manufacturer in a problem which has not only proved very fascinating as a piece of scientific research, but which is, in my opinion of supreme importance.

It may be useful to state in conclusion that manufacturers have expressed considerable interest in the results obtained and on all sides have added confirmation to the results obtained at the Agricultural Department.

One other fact, to which reference has been made before, in connection with the advantage of preparing "slab" rubber, is that lump or cup and bucket coagulation can be mixed with first latex rubber, since this rubber if left for the maturation period before crêpeing is essentially "slab" rubber. This means, therefore, an increase of first grade rubber, and should prove especially valuable on those estates where natural coagulation is abnormally great.

Discussion.

Mr. PINCHING asked Mr. Souter what he meant by standard latex.

Mr. SOUTER explained that he meant the standard that he was accustomed to in his factory.

Mr. EATON, in reply to Mr. Pinching, explained the need for managers to carry out investigations into the latex standards of their estates, and also replied to certain questions asked by Mr. Malet in regard to the influence on rubber of dampness in the factory.

Mr. IRVING said that, apart from the minor points raised so far, Mr. Eaton's paper was of prime importance in regard to the valuable information he had given them regarding what he called "slab rubber." He asked whether any steps had been taken to ascertain the views of manufacturers on the matter.

Mr. EATON replied that they had taken no definite steps because manufacturers at Home were at present very busy in regard to war work and could not be induced to deal with matters of that kind till after the war. But American manufacturers had always taken interest in such things and a few of those engaged in the industry here had even tried the method he had explained. He stated that about half a ton of that rubber in the form of crêpe had already been forwarded to one of the best known rubber manufacturers in America for their opinion but so far nothing had yet been heard in reply. He also understood the American General Rubber Company was sending forward rubber of this kind to their own rubber factories in America. A further point he wished to emphasize in regard to his previous remarks in the paper was that, as the rubber he had mentioned usually required rewashing, it could be packed in gunny bags, which would mean an additional saving in cost. According to experiments which he had recently carried out, the best method of preparing "virgin slab" was to hot air dry it at about 120° to 130° F.

A member asked whether the General Rubber Company's product was in "slab" or crêpe.

Mr. EATON said he believed it was "slabs" $\frac{3}{4}$ inch thick.

COCONUTS.

OBSERVATIONS ON COCONUT EXPERIMENTS.

By G. E. Coombs, B.Sc.
(*Economic Botanist, F.M.S.*)
AND
W. S. Cookson,
(*Manager, Dindings Coconut Estates, Dindings, S.S.*)

AS a Conference subject this subject is almost ideal as heretofore experiments in coconut culture have been laid down on any but uniform lines, and an occasion of this nature provides opportunity of indicating—for purposes of discussion—some of the guiding principles which should direct the evolution of methods.

The experimenter in agricultural science and in particular the experimenter in that part of the science which deals with crop production, where experiment is directed to the causation and actual measurement of increase of crop returns, has to approach his object with extreme caution, for he is called upon to work with material of widely varying natures and, if the extent of these variations is not examined critically he is exceedingly likely to arrive at erroneous results.

It is a point of fundamental importance that before judgment in the sense of an expression of actual measured yield-effect, can be passed on the values of different treatments given to any crop, the facts of the variation in yield which blocks of the crop show under as far as possible uniform conditions must be determined. With this knowledge, logical interpretation may be placed on results obtained. The method has been evolved to a high degree of perfection in experiments with annual crops and in this case accurate experiments can be carried out on land of small dimensions, but the case of permanent crops, *e.g.*, fruit trees, though amenable to precisely similar methods, presents added pitfalls and difficulties.

The factors which determine production of fruit in any stand of trees are:

(1) The constitutional natures of the trees. Any block of them, unless they are of pure stock, may contain a number of varieties or sub-varieties of varying productive powers; these varieties will contain individuals of varying productive powers; and this cumulatively variable individuality, may be expressed by the presence of very precocious bearers and those approaching sterility.

(2) The factors which govern pollination and fertilization, It will be seen that the more precise the method of pollination, be it for example a case of unfailing insect pollination the less will be the variations expressed as a result of it.

(3) Various cultural factors such as soil, water supply, climate, etc.

Of these three groups it will be evident that group (1) presents great difficulties, and the effect of the individual in the fruit production of any set of trees on a limited area may be very great and almost of itself decide the dimensions of the experiment.

In experiments of the nature under discussion there are two distinct problems, the one of patches of backward palms—palms obviously "not doing" as shown by their general appearance—and the other of the stand of good palms. This latter is again two fold in its aspect that of the young and that of the old palm.

As concerns the former, the planter being aware of the cardinal points of coconut culture, knows in a general way the physiological requirements of the palm. He can often make a very shrewd guess at the cause of the backwardness of any one pocket of palms; he knows the value of an extra drain here and of a little cultivation there as means to improve their condition, and can achieve much good by intelligent application of the knowledge of husbandry which he possesses; and though he is the first to acknowledge that he is often quite unable to speak of his results in terms expressing actual measurement, the fact that he actually achieves good will not be denied even by the scientific purist. But what may be spoken of as agriculture in its best sense deals with issues far less clearly defined than these. It deals with the detection of differences of much smaller magnitude. This being so it must be acknowledged that personal judgment on the best forms of cultivation, on the values of different leguminous cover crops or different manures, or on the much disputed point of clean weeding in an estate of uniform palms is but a flimsy deciding factor; these, however, are the very points which the investigator in his efforts to make a good stand of palms yield yet more, is called upon to decide. The differences in nature of these two problems have hitherto not been sufficiently appreciated. It is the latter problem with which these observations deal. As mentioned above the problem is a dual one. With respect to the problem of the young palm it is a matter of recent history since the Department of Agriculture was asked to undertake a comprehensive series of experiments on young palms. The problems put forward for solution were the values of different kinds of manures, of different leguminous cover crops, of different forms of cultivation and of combinations of each of these treatments, a large number of varied treatments being

involved. It may, therefore, be of advantage if the arguments which prompted the demand for caution, and asked that a number of preliminary records might be obtained prior to the formulation of any actual scheme—avowedly theoretical though many of them then were—are given.

Reference has already been made to the mixed natures of the palms in any field of an estate, and the manner in which their individual capabilities would affect yield has been indicated.

We have to add to this, however, the variation which will be caused, the extent has as yet not been investigated, by the varying periodic productions of the palms before they reach their periods of stationary production.

Thus a quantity of palms will commence fructifying at a particular period; these will show a definite incremental curve to the attainment of a more or less stationary maximum production which will be attained in a more or less definite time; but for each of the different sets which fructify at different subsequent periods there will be an incremental curve possibly different from the others, as there will be different periods up to their "stationary productive stages." Add to these the variations which may be attributed to chance pollination and it will be seen that the following variables have to be considered:

(1) Variety of palm,

(2) Individual palm,

(3) Time of initial flowering,

(4) Time of attainment of stationary yield,

(5) Lengths of periods between (3) and (4),

(6) Pollination,

(7) Culture,

and, in a crop such as this where the ultimate gain comes down to "oil content,"

(8) Copra and oil content at various stages in growth, *i.e.*, physiological considerations.

Though as far as can be ascertained no work of analytical nature has been done on the "populations" of palms in estates, and the effect of many of these variables may ultimately prove to be of small dimensions, it seems a moral certainty that the method of division of a stand of young palms into blocks, giving different treatments to some of the blocks and using others as "controls," even if a large number of the latter are taken, will for the detections of small differences due to culture be of very little, if any, utility. It appears perfectly useless to speculate on blocks of palms averaging up; it seems a matter of pure chance to count on any sympathy being

shown in the trend of the yield—curves of controls. The facts *have* to be investigated. Results of utility could be possibly procured after a number of years but on the lengths of the period it is difficult to hazard a guess.

Some of the facts are being investigated on Tumbuk Estate (Mr. F. H. Dale) and will, it is hoped, be communicated from time to time but the difficulties of any manager in executing work of this kind are very great.

The case of old coconuts presents a simpler issue. After a period of years of bearing the palms reach a stationary maximum-production-period which we may assume is a fairly long span ere the loss of fruit due to oncoming senility supervenes. In the absence of records, it would perhaps be safe to assume, that after 10 to 15 years, all the palms in any field of an estate would have reached this stage or have so nearly approached it as to cause little fluctuation, and now the disturbing factor so bafflingly difficult in the young palm is excluded. Thus it becomes possible to procure more comparable data of the yields of blocks of palms over a period of time, the collection of which data constitutes the preliminary work mentioned above as a basis on which to calculate the size of experiments for the attainment of results of accuracy.

Without going into the long explanation as to the particular method it may be stated that this has actually been done on Gapis Estate where by taking preliminary records of yield over a period of six months, it was possible to initiate experiments on eight blocks of 100 trees each, using two as controls, and one pair each for the trial of three manures, in the detection of differences over 15 per cent.

In Ceylon experiments have for some years been conducted on a basis—not of absolute yield—but of proportionate increase in plot-yields from period to period, that is, that each plot used has been used largely as its own control. There is little doubt that this method provides information of great utility. Manurial treatment to permanent crops is a cumulative business and records over a period of years on blocks of palms irrespective of control plots gives very useful information. In the Chilaw experiments recently published the yields from January to February in two consecutive years were compared, the result of treatment being displayed in proportionate increase in yield from January to February of one year to January to February of the next year. The method given as in vogue there is not without its utility in the detection of differences of considerable magnitude, but there its utility (and in this particular instance it is well illustrated) seems to end, for the yields of the plots untreated show tremendous variation and the causes of these are quite unexplained. It seems impossible to put any general interpretation to the results obtained.

Turning to methods in use in the West Indies we find an extremely helpful article in the *Agricultural News* for May 1916. Here the writer brings out very forcibly the value of uniformity of method. Thus:

"It is thought that were there more uniformity of methods amongst investigators, there would in all probability be much better agreement as regards results. There has been too strong a tendency in the past to lay out manurial experiments according to personal ideas rather than to scientific ideas.

"With present methods the truth about the effects of manures on trees can be more usefully expressed in words than in numbers?"

This latter fact is as true as it is desirable that it be changed. If investigation has not gone far enough to provide data sufficiently precise on which to base actual yield experiments, then it is our task to initiate work which will have that end in view. The way may be long, but it will undoubtedly pay in the long run.

As concerns the method in use in Trinidad and Nevis, both of which are outlined on the article quoted, to which attention is strongly urged, it appears that they also cannot be expected to produce accurate results. The two methods are given as follows:

(1) Trinidad—

Gain or loss $= \{(V_1 - V_2) - (C_1 - C_2)\} - m$

Where V_1 = value of yield from manured plot, say ... ... 1915-16.

V_2 = value of yield from manured plot, say ... ... 1914-15.

C_1 = value of average yield from two control plots, say ... ... 1915-16.

C_2 = value of average yield from two control plots, say ... ... 1914-15.

m = cost manuring.

(2) Nevis—

Gain or loss = value of $[\{n + (n_2 - n_1)\} - c] - m$

where n = average number of nuts per tree picked between two annual applications of manure.

n_1 = average number of nuts per tree picked at beginning of experimental year.

n_2 = average number of nuts per tree picked at end of experimental year.

c = the $n + (n_2 - n_1)$ value of the control.

In the case of the former, the value of the results seems dependent on the uniformity of the yields of the two control plots and their agreement with the yield of the plots now treated in the years prior to their treatment, while in the case of the latter the use of the control is quite subordinated, one only being used, and no indication of the range of variation or the causes of variations in the plots under uniform treatment is obtainable.

As far as published results go, and certainly as far as theoretical considerations direct experiment, the only rational way where experiment is framed on yield estimation (there are numerous cases where growth-record experiments may be used to advantage) seems to be the utilization of the results of an initial investigation of yield-differences over a large number of blocks of palms similarly treated, and the value of controls as a check certainly seem to lie in the detection of the range between their maximum and minimum values.

It is difficult in a paper of this nature and length, to indicate clearly the interpretation which the experimenter will put to his records, but the citation of the points above mentioned may not be without interest in the light of what follows.

Taken together they lie at the basis of the problem which every estate manager is confronted with, *viz.*, estimates—the one concerning which he thanks his good fortune if his figures of crops for any period in advance approaches the figures of the actual crops produced.

It has been mentioned previously in this paper, that experiments are in hand to investigate the question of the incremental-crop produced in young palms. Whatever values may be ultimately determined by experimentation as being theoretically possible, there is the ever present fact that the arrears in the number of ripe nuts obtained under present conditions and methods are disproportionately great, and here we approach the question of "falling nuts." So far, the actual numbers have not been obtained for mature palms but it is extremely probable that they are of high magnitude. In general the nuts which fall may be placed into the following categories:

(*a*) Those which are unpollinated and therefore unfertilized;

(*b*) Those which are pollinated but in which fertilization does not eventuate;

(*c*) Those which are pollinated and fertilized but which are thrown off in the run of the physiology of the tree for reasons of the trees' inability to carry them. Nutritional factors—water supply in particular—will here play an important part, and may possibly largely determine periodicity in crop production.

In young palms category (*c*) will probably account for a larger number than has been previously supposed and similarly in the case

of old palms with defective nutrition but there seems little doubt that by far the greatest number may be accounted for by actual lack of fertilization and from the observations which it has been possible to make, of these the over-whelming majority are those in which pollination is never affected, *viz.* (*a*) above.

It is a fact of general observation that in tropical flowers, those in which pollination is never effected predominate in very large numbers over those in which it actually takes place.

Though the facts are not worked out and these arguments are somewhat speculative (they are quoted merely for the purposes of discussion), it seems safe to assume that "nuts" which actually swell to the size of a man's fist, have been fertilized. There may however be, and probably is, swelling in the sense of growth taking place, during the interval between actual pollination and fertilization, but these facts are as yet undetermined.

Actual fair-average counts made on three estates in the country disclose the following figures for falling nuts in a year's crop of 4-4½ years old palms. Dindings 50-60 per cent., Bagan Datoh 60-70 per cent. and Tumbuk 50-60 per cent. In discussing the magnitude of the effect of the contributing causes the following observations on the pollination of the flower may be of interest. The flower is dependent for its pollination on insects or on wind. As an insect flower it falls short of the general attractive mechanisms of scent showiness, and produces only a very small quantity of nectar. As a wind flower it lacks the generally present pendulous stamens, the much expanded stigma and other characters, though it produces a prodigious quantity of smooth pollen. Indeed, nature seems to have provided a means anything but precise for this particular palm, and it seems fairly conclusive that this is the reason which may be ascribed above all others to the cause of falling nuts. If this is the case then it is very evident that variations in climate in this country may have a less far reaching effect than has hitherto supposed in deciding periodic production. The problem is full of interest and it is here suggested as being of great importance. On one side we hear the behest "Keep bees, you will ensure a fuller crop" but the query raised by the other side as to where to find this actually demonstrated is as yet un-answered. The matter should be worked out by a botanist and entomologist in co-operation. At the moment some experiments on hand-pollination are being executed. The field is practically clear and there are a number of pressing problems. These include the collection of data on the productivity of varieties and individuals carried out to the final oil-content factor, as a basis of seed selection; the productivity of hybrids on the lines of Henry's work, the causes of periodicity, the utility of the prevention of first fruitings as an insurance for larger subsequent crops, the causes of sterility, the question of toxicity of grass, the utility of leguminous covers on various types of soil, etc. All of these open up other

issues to the worker on biology. Whether the work the results of which can but be on the main a heritage for others is worthy of execution will perhaps be decided by those whose immediate interests are involved. These remarks, many of which the authors agree are raised on matters uninvestigated or unproven will not be valueless if they merely stimulate interest.

Discussion.

Mr. R. W. Munro said: If I may make a passing reference to the last paper, I wish to say that it is a most instructive as well as a valuable contribution, for which both Mr. Coombs and Mr. Cookson deserve our thanks. We know that Mr. Cookson is very keen on this branch of agriculture—(hear, hear) but he is not in the country at present, and we are sorry that we are not able to discuss it now so much as we should wish to. We hope, however, to have it printed and we can then study it. Some of the remarks that Mr. Coombs read to us have an application to other products as well.

HEALTH AND SANITATION.

HEALTH AND SANITATION ON ESTATES.

By Dr. S. H. R. Lucy,
(*Senior Health Officer, F.M.S.*)

IN considering the problems connected with sanitation upon estates in the Federated Malay States I propose in the first instance to speak from the point of view of a sanitarian concerned with the opening up of virgin jungle for cultivation and the employment thereon of immigrant labour.

Site for Cooly Lines.

Much trouble and expense in the future may be saved by a judicious choice of site for lines, it is within the experience of many of you, for one reason or another, generally the occurrence of severe malaria, that it has become necessary to abandon certain line sites, much financial loss being thereby entailed, especially when the lines and wells were built of permanent materials.

In the early days of coffee or rubber planting it was the common practice to choose for a line site the edge of a ravine or swamp, the main factors which determined this choice being the easy access to water, a shallow hole in the ground provided a sufficiency, or the unsuitability of the land for cultivation.

In the first stages of opening an estate it must often be impossible to fix upon a permanent line site, it is however not usually difficult to find a temporary site that has no obvious disadvantages, the main points to be considered are accessibility, configuration of the land, and its relative distance from ravines, swamps, and alienated or unalienated land over which you will be unable to exercise any control.

Accessibility.

A central site may be too remote to suit the convenience of your coolies, but it renders more easy the work of your labour gangs and a site which abuts upon a busy road or crowded village may present many objections.

Within limits there can be no doubt that concentration of your labour is desirable, where there are congregated large numbers of coolies they are healthier and happier than when scattered about the estate in small parties. Concentration facilitates supervision, it used to be considered a danger in the case of an outbreak of

contagious or infectious disease, in practice this is not the case, the permanent materials of which lines are now constructed are readily disinfected. The line site should be flat, clean weeded and free of all cultivation. There should be not less than 50 feet between each set of lines and at least 200 feet between the lines and the cultivated area. If this allowance of open space is made it will be found, that for say six sets of lines of 20 rooms each, about six acres will be required for the line site. That is none too much for the accommodation of nearly 500 persons but it is a great deal more than is afforded upon the majority of estates where the mistake has been made of planting up close to the lines with the idea that the rubber can be cut back later on, only too often the manager is unable to harden his heart when it has come to cutting out rows of trees well grown and ready for the knife. It must never be forgotten that the lines will, as time goes on, become surrounded by a dense wall of cultivation which in the case of rubber may be 40 feet high and unless that wall is far removed from the lines the labourers will not get sufficient light, air, and sunshine. Apart from a deficiency of these three essentials to health there is in this country a special danger from cultivation close to cooly lines for it means that the ground adjoining the lines remains damp and in the rainy seasons sodden, conditions eminently suitable for the propagation of hook worm disease. In this connection it should be remembered that the direct rays of the tropical sun have most powerful sterilizing properties. Labourers will acquire no disease from contact with a clean weeded sunbaked line site, a grass grown site may be more picturesque, but refuse rice and debris from the lines will be deposited in the grass, flies will breed in it and become a nuisance and a dangerous factor in the spread of diarrhœa, dysentery or other intestinal complaint. There should be plenty of light in the lines, unfortunately both coolies and anopheline mosquitoes prefer darkness and gloom, light will not hurt your coolies but anophelines will and it is therefore well to insist that light shall not be blocked out of the rooms. A further valuable precaution is white-washing of the lines within and without at frequent intervals. It has often been noticed that anophelines are difficult to find in white-washed rooms whilst in adjoining rooms that have not been white-washed they may be found in numbers. In this country anophelines certainly avoid bright daylight and sunlight. It is stated that in the Panama Zone anophelines will remain hungry rather than fly three feet out into the sunlight to bite a person standing in the sun. In the choice of a line site it is important to avoid the proximity of ravines and swamps. Ravines may afford a water supply, they will certainly produce malaria. Swamps are less harmful, and it may be said that ravines and grass grown ditches in which there is a trickle of clear water should be looked upon with greater suspicion than permanent swamp or old

mine holes. Hill sites are unsuitable, there are usually ravines at the foot of the hills and in any case coolies don't like hill tops, they are too cold for them.

The boundaries of an estate should be given a wide berth for whether your neighbours are the Government, another estate or native holdings you cannot control their actions, all your sanitary measures may be in vain by reason of the omission of your neighbours to adopt suitable precautions.

It is not possible to state at what distance from ravines or swamps it is safe to house your labourers, we do not know what is the diameter of the magic circle the centre of which the anopheline will fail to reach, but it is certain that the further your lines are from their breeding grounds the less trouble will you get from malarial fevers.

The management of an estate situated anywhere in broken hilly country will be amply rewarded in the future for any amount of trouble, taken in the earliest stages of development, to find a spacious and flat area of land and to reserve it as a line site. The disregard of this measure of prudence is common, it has been and will continue to be a source of serious embarrassment and expense, there are comparatively few estates the labour forces of which are housed upon the best available site on the property.

A good deal of emphasis has been laid upon this matter of the choice of sites for lines on account of the extremely important bearing that it has upon the health of labourers and further for the reason that, the immediate outlay entailed by the abandonment of lines which have been put up on an ill chosen site and the erection of new lines upon a fresh site which is generally under well grown rubber is rarely faced. Estates go on year after year expending money upon attempts to improve the sanitary surroundings of their lines, all of which expense might have been avoided by the exercise of foresight in the early days of development.

Cooly Lines.

Of the three common types of lines in use the plan to be adopted is not generally of great importance. On those estates where the level of the subsoil water is very high, raised lines are to be preferred, this type admits of cooking operations under the lines and the smoke from the wood fires has some deterrent effect upon mosquitoes, coolies have been known to complain of the cold in these raised lines, another complaint is that the height of the steps or verandah is a danger to their children, a more common and real disadvantage is the difficulty that there is to ensure that the space under the lines is kept clear of obstructions and in a reasonable sanitary condition, coolies will board up the space for the purpose of keeping their cattle, goats or fowls and constant supervision is required to prevent it.

The ground floor type of lines seems more popular with coolies and it has the advantage that it is readily supervised and kept clean. Overcrowding of lines must be avoided, a minimum of 30 feet of floor space for each person must be insisted upon. Regular inspection by a responsible person is necessary, where this is neglected the lines will become dirty and evil smelling, and what is even more serious light and air spaces soon become blocked up by boarding, sacking or other obstruction.

The question of sites for bungalows must next be considered, the choice and maintenance of suitable sites for the European staff is no less important than for the labourers, frequently too little consideration is given to this matter. Many of the quarters of the managers and assistants are unsuitably placed on sites which are hemmed in at a few yards distance by dense and lofty cultivation. Apart from a lack of sufficient ventilation upon such sites and the increased nuisance and danger from mosquitoes which find a safe harbour in the rubber around the house, the depression to mind and body from living amidst these surroundings has a very adverse influence upon the health, even the occasional visitor to estates must have been struck sometimes at the sombre gloom of an old rubber clearing. Europeans cannot live and thrive in such environment and to expect from them continuous good work and good health is to expect the impossible. A large clearing should be made round each bungalow, it is unnecessary to up-keep extensive gardens but the wages of a one or more coolies to keep cut a few acres of grass-land round the house should never be grudged.

Water Supply.

An ample supply of good water is a valuable asset and is worth much trouble to secure. When coolies can get plenty of good water for both cooking and bathing purposes at or near their lines they are less likely to make use of ditches, ponds, or streams, when in the field. Most of the rivers and streams in this country become highly polluted soon after they have left the hills in which they rise, it is therefore of very doubtful advantage to have a stream running past the lines, nothing will stop the coolies from using it and its purity must always be suspect. The best sources of supply are from protected hill catchments, the water being brought to stand pipes at the lines, the great value of such a supply is evident, it is usually almost unlimited in quantity and its purity is generally above suspicion. The initial outlay for construction of head works and laying of pipes may be considerable but the expenses for upkeep are small. Upon those estates where such installations exist the management is relieved from much anxiety which is inevitable when shallow wells of uncertain purity constitute the only source of supply for a large labour force. Where a hill supply is impracticable wells must be sunk and it is advisable to have bores put down in order that

an adequate supply at a good depth may be located. Water can be found by digging a few feet below the surface almost anywhere but these shallow pits, they cannot be called wells, do not afford a safe supply and if dug during the wet season they are apt to fail in the dry. All shallow wells, that is wells less than 50 feet in depth require most careful protection against pollution by surface washings or soakage from cess pits. For the lining of wells concrete cylinders should be used rather than brickwork, concrete is less porous than brick and the use of concrete cylinders renders any subsequent deepening of the well more easy than if brickwork is put in as a lining. The greater depth to which the concrete cylinders are sunk the less likelihood will there be of contamination from the surface. In no case should these cylinders be sunk for less than 15 feet. It is not desirable that wells should be close to the lines, freedom from contamination must be secured and the nearer the well is placed to the lines the more difficult does that become. Wells should be far removed from the outfall of line drains, latrines, cattle sheds, and rubbish pits. The ground surrounding the well should be guarded from gross pollution for several hundred feet. A pump is a necessity and it is recommended to procure it from a reliable firm and to pay a good price for it, cheap pumps are quite unsuitable for estate use, they are rarely in working order for more than a few months. A light cover should be placed over the well, this should not exclude air, it is intended to prevent accidental or deliberate fouling of the water. The discharge from the pump should be at a distance from the well and should be provided with a concrete platform sloping to an impervious drain to take away waste water.

Conservancy and Rubbish Disposal.

Some system of night-soil disposal is a necessity, labourers must not be permitted to foul the ground by indiscriminate defæcation—a habit to which they are accustomed but which they must be broken of. This fouling of the soil is a real danger to health, it conduces through the agency of house flies to the dissemination of dysentery, diarrhœa, typhoid and other complaints. The repeated contamination of the soil by fæcal matter inevitably tends to the propagation of hook worm disease and that disease in conjunction with malaria is a grave menace to the efficiency of a labour force. Latrines of whatever type adopted should not be far from the lines, the closer they are placed the better, provided of course that where pits or trenches are used they are outside the line reserve. Latrines should afford plenty of accommodation, those for men and women should be separated and sufficient shelter for decency's sake should be provided by the use of screens. Latrines must be roofed over to protect them from rain, they should also have drains dug round them to keep out storm water. A liberal supply of lime must be used to prevent the breeding out of flies. Pit or trench latrines must be placed at a

good distance from the wells. When possible the well should be on the upper slope and the latrines on the lower slope of the line site. Cooly lines cannot be maintained in a proper sanitary condition unless it is the special work of some one to keep them so, one or more line sweepers must be employed whose daily duty it is to sweep out the drains, collect all refuse, rubbish, tins and bottles from the line site and its surroundings and dispose of it by burial or fire. It is a good plan to have trenches dug between the rubber in which the refuse is thrown and covered with earth each day. The line sweepers must also attend to the upkeep and liming of the latrines, if bucket latrines are in use they should bury the night-soil twice daily at sites which have been selected for that purpose.

The Care of Labourers.

Whatever class of labour is recruited each batch should be medically examined as soon as possible after arrival on the estate and all coolies should be rejected who, in consequence of disease, infirmity, or malformation, are found to be unfit for agricultural labour. The prompt medical examination of locally recruited coolies should never be neglected, these local coolies have often drifted in from highly malarious districts and in that case they are certain to be infected in a greater or less degree with malaria. It may not be necessary to turn such coolies away but it is essential that they shall receive special treatment with quinine if they are to be absorbed into the estate labour force. New recruits from the Coast are usually entirely ignorant of the art of food preparation, many of them have eaten rice for the first time at the Coast depôt and still know nothing about cooking it, they are moreover very susceptible to malaria and bowel diseases. It is therefore a wise custom to supply them with cooked rations for not less than six months after arrival, the requisite arrangements entail some little trouble and supervision, but they do not involve any great expense. It may prevent the serious disorganization of a labour force which results from a high sick rate. A daily quinine ration should be given to all new recruits for a similar period. Upon estates where malaria is severe and quinine is given at the hour of morning muster it is well worth while to provide a ration of hot coffee or congee at the same time, large doses of quinine should not be given on empty stomachs, they produce unpleasant consequences and coolies are apt to evade their doses if it is so given. Unless the management makes provision for a hot ration the quinine is commonly taken either on an empty stomach or else on top of a handful of stale and sour rice left over from the meal of the previous day, in neither case can good results be expected. These preventive measures may be thought to be needless for universal adoption in the comparatively healthy Coast districts, but in the malarious country near the foot hills they might with advantage be carried out as a matter of routine by the estate management.

Malaria.

In its many phases malaria is unquestionably the most serious adversary of the planting interests. It is the one disease which permanently cripples a labour force. When it does not kill outright it may so reduce the vitality and physique of the coolies that they fall ready victims to intercurrent affections such as dysentery and ankylostomiasis. Malaria is conveyed to man through the bites of anopheline mosquitoes, several species are known to be malarial carriers. It is probable as our knowledge advances that other species not at present known to carry infection will be found to be in fact capable of so doing.

For practical purposes all anophelines must be taboo, no effective measures for their extermination or reduction should be neglected. We do not know very much about the habits and capabilities of anophelines and for that reason it is unwise to dogmatize as to the best methods to be adopted to control them. We do know that in Panama anophelines have been found to be swift and strong on the wing and to cover great distances against or even at right angles to the wind in order to obtain human blood. It seems certain also that they avoid strong light, especially bright sunshine.

Conditions are so varied that no single system of anti-malarial measures can be laid down as applicable to all estates. Apart from a judicious choice of line sites, already referred to, there are three principal measures that may be mentioned, these are quinine prophylaxis, oiling, and piping. One or other measure may be all that is necessary but it will commonly be found that a combination of two at any rate is indicated.

The regular medication by quinine over a prolonged period to an estate labour force is no easy matter. It can be relied upon to be effective only when the distribution is under the direct supervision of a manager or assistant. It is a common experience to be told that all labourers get quinine daily and to find that actually only those complaining of fever get quinine and that they get it only so long as they are sick. Where malaria is prevalent the children are certainly infected, it is therefore imperative that they and also the "dependants" should be given the quinine ration.

The spraying of mosquito breeding grounds by means of an oil vapour is becoming more popular, it is, when combined with the clean weeding of streams and ravines, a very effective means for the destruction of mosquito larvæ. In addition it is a method which has the advantage that it is easily extended at a small additional cost. Oil spraying is certainly the most generally suitable measure of mosquito reduction upon estates and rural areas.

The plan of conducting under ground all surface water is without doubt the ideal one for the abolition of malaria. The success of this system is, however, beset by many difficulties. It is at

present undetermined over what distance must pipes be laid in order to free or produce a marked reduction in anophelines in a given area. Serious "washes out" of the pipe lines may occur during floods, the formation of pools and pot-holes by the scour of flood water entails unremitting attention and upkeep. Unless these facts are thoroughly understood and appreciated much disappointment will ensue and a word of warning is necessary lest the management of estates should rush into ill considered and expensive piping operations with the conviction that the laying of a certain number of chains of underground pipes is a panacea for malaria and that all other sanitary precautions may be neglected.

Although medication by quinine, oil spraying and piping have been referred to as the principal measures of prevention against malaria there are many others which cannot be neglected. Extensive swampy areas may often be dried up or greatly reduced in size by cutting a few drains through them. Natural water courses and ditches should be canalized, trained and clean weeded, small depressions and hollows which in stiff soils are apt to retain water should be filled or levelled. Agricultural drains will require constant attention to avoid silting up and the formation of pot-holes and back waters. Scrub and undergrowth must be cut down, for these afford shelter for mosquitoes and favour the formation of small pools and puddles by retarding evaporation. There is no one specific remedy for malaria, only by an intelligent combination of methods which have been proved to be of practical value will good results to be attained.

Medical Supervision and Hospitals.

The prevention of sickness is the first and all important duty of the medical adviser to an estate. In theory it should not be necessary to make arrangements for the treatment of a number of sick coolies. Apart from accidents which will occur in spite of all laws and codes the sanitation of an estate should be so efficient and complete that disease has no chance of a successful attack upon the labour force. There are, however, few estates in this fortunate plight. There are many on which the sick rate is extraordinarily low, it is possible that the happy state of comparative freedom from disease on some of these favoured estates may be attributed to the natural salubrity of their surroundings rather than to the perfection of the sanitary measures that are in force. But we must take things as we find them and on the vast majority of estates there exist conditions which may become inimical to a continued high standard of health in the labourers employed. It is the concern of the medical adviser to the estate to combat these adverse influences and reduce the potential sources of sickness and mortality to a minimum. The main business of an estate doctor being the prevention not the cure of disease, it is evident that this object cannot be attained if the whole of his energy is directed to

the medical treatment of such cases as he sees upon occasional visits to the estate hospital. It is of the greatest importance that there should be a regular medical inspection of lines, drains, latrines, water supply, any anti-malarial works that may be in hand and all other sanitary arrangements. Of no less importance is it that the coolies should from time to time be mustered and inspected by the doctor. On estates where there is little sickness a muster once a quarter is sufficient, but where there is much malaria, in spite of the inconvenience inseparable from a complete muster of the labourers, it is essential that the medical adviser should see every cooly not less than once a month, by this means alone is it possible for him to form an opinion as to the general health of the labourers, the effectiveness of such preventive sanitary measures as are in force or the necessity for further efforts.

In addition to regular visits from a medical practitioner it is the custom on larger estates to employ a dresser, a reliable man should be engaged for his duties are important. The dresser should be present at all musters, he should attend to the minor ailments of the coolies and supply them with simple remedies. If a quinine ration is given he must keep a quinine check-roll in which should be included the names of all labourers, dependents, and children. He must visit the lines not less than once a day to see that they and their surroundings are clean and that the line sweepers keep the drains and latrines in good sanitary condition. Not the least important duty of a dresser is to account each day for all labourers, especially any who are absent without leave from the morning muster or working parties. All rooms should be searched for sick labourers or dependents and every case of sickness immediately reported to an assistant or the manager. A highly skilled dresser is not necessary, he will be apt to keep sick coolies on the estate under his own treatment and report them to the manager only when their condition is beyond his efforts and not improbably also those of the hospital staff. The dresser should find all coolies who through illness are unfit to work and report them to the manager, but the responsibility to obtain prompt hospital treatment for the sick must rest upon the manager and cannot be shifted to a dresser.

Hospitals.

It is obligatory upon all employers of native labour to make suitable arrangements for the hospital accommodation of the sick. In the tropics especially diseases are difficult of diagnosis and they are usually rapid in their progress, the treatment applied in the first twenty-four hours frequently determines the issue of the case. It is, therefore, essential from a humanitarian and not less so from an economical standpoint that prompt and skilful medical relief shall be available for the sick. Where small hospitals are put up on each estate they do not discharge these requirements, there can be no

question that the multiplication of separate estate hospitals is from every point of view an unmitigated evil. These small hospitals will be ill equipped and indifferently staffed, apart from an occasional visit from a medical practitioner the patients will be at mercy of men who are unfitted by education and experience to be in sole charge of dangerous cases. To spend much thought, time, and money on sanitary measures on an estate for the purpose of keeping the labourers in good health and then to commit the unfortunates who do fall ill to a hospital where they may have to wait a week before receiving any expert medical treatment is neither good logic nor good business. I cannot too strongly urge the creation of few large and well equipped hospitals to serve the needs of groups of estates, rather than a multitude of small hospitals which are such only in name.

Personal Hygiene.

A planter's chief concern is for his labourers and he is not seldom careless of his own health. In addition to the necessity for roomy quarters in a carefully chosen and extensive clearing and a water supply that is above suspicion, it advisable that there should be a screened room in every bungalow, it should be not less than 14 feet square so that it can accommodate several chairs and a table, it should be provided with a double swing-to door. The room should be so placed that it is open on three sides, it should be provided for when the house is planned, the small extempore mosquito proof rooms commonly put up are fit only for meat safes, it is little wonder that they can seldom be used for the purpose intended. Malaria is the cause of at least 90 per cent. of the sickness and invaliding among planters and no precautions against this disease must be neglected in those districts where it is prevalent. Anopheles bite chiefly in the dusk of evening and early dawn, spend these dangerous hours when practicable in a protected room. Never sit about in the open after sunset, especially after tennis or other exercise. Protect the feet and ankles from mosquitoes during the dinner hour by boots or other device. Never sit about in wet clothes, a chill is the most common determining factor in the onset of an attack of malaria. Do not consider the use of a punkah or fan to be a luxury, they are valuable aids to health of mind and body, any one who fails to make use of them is culpably negligent. Take a dose of quinine daily, if you suspect you are suffering from malaria do not rely on the thermometer but consult your doctor who will make sure about it and give you the necessary treatment.

Labourers and Statistics.

In certain areas of intense malaria it has at times been found necessary to substitute Chinese for Indian labour. Chinese for various reasons oppose a stout resistance to malaria and bowel complaints, they can live and work and remain in comparatively good health in places where Indians wilt and die. On the other

hand, it has been shown beyond question that vigorous, intelligent and persistent anti-malarial measures carried out by a manager who has a full knowledge of their value and belief for their necessity will bring about so great a change on a highly malarious estate that not only is it practicable to re-employ Indian labour but the sick rate and mortality from malaria can be brought to very moderate dimensions.

The accompanying table sets out the death-rate among Indian labourers in the Federated Malay States during the past six years—

Year.	Average number of Indian estate labourers.	No. of deaths.	Death-rate.
1911	110,000	7,162	65 per mille
1912	122,000	5,014	41 „
1913	133,000	4,057	30 „
1914	128,975	4,070	31 „
1915	120,107	2,511	20 „
1916	130,840	2,788	21 „

If we consider the figures for labourers of all nationalities, Indians, Chinese, Javanese and Malays the reduction in mortality is even more marked but the figures are not so reliable. The Indian figures though they do not include the deaths of infants or dependents are very encouraging. To bring about still further progress there are three prominent measures to which special effort should in future be directed. These are, an extension of anti-malarial works, a more prompt removal of the sick to hospital and an increase in the qualified medical staffs of estate hospitals. The marked reduction in Indian mortality upon estates during the past six years is a great tribute to the successful and earnest endeavours of managers, assistants and their medical advisers, it will doubtless also serve as a stimulus for further effort.

Discussion.

Dr. Lucy concluded his paper by inviting questions and specially asked two members whom he knew had experimented with oil to state their experience.

Mr. Harrison said that he had tried oil on Midlands Estate with very satisfactory results.

During 1911 the death-rate was 25 per mille, but during the past few years it had been greatly reduced by this means and now amounted only to 1.5 (Hear, hear). That was not due entirely to oiling, but mainly to it, as other methods of subsoil drainage, etc., had also been tried. It was Dr. Watson, who had visited Panama, who suggested oiling. They first tried crude kerosene. They now had their place oiled once a week, costing from $500 to $700 a month for about half a mile around. While they had had a hospital admission rate of 50 per cent. previously it was now reduced to 2 per cent.

Mr. GILMAN, who had also tried oiling on Bukit Jelutong Estate, said that, when he started, the death-rate on his estate in August, 1915, was 88 per mille, at the end of that year it came down to 69. In 1916 the death-rate was 3 per mille. This year they had not had a death yet. He had 159 coolies and only had one death, from pneumonia, during the year.

Mr. HUSON asked for more information about the method of spraying.

Mr. HARRISON explained that he employed four coolies in each division with four sprayers, with a definite programme mapped out for each. They used crude oil in 65-gallon drums which were used for liquid fuel. One ordinary kerosene oil tin filled a spraying machine. Every scrap of water in the area was oiled, in fact they even went across the road into the surrounding kampongs and oiled the wells there. (Laughter.)

Mr. JARVIS thought the experience of Midlands, where half a mile of oiling was sufficient, did not agree with the statement that in Panama anophelines would fly a mile against wind, and asked Dr. Lucy what he considered was the limit of a mosquito's operations.

Dr. LUCY replied that as to mosquitoes travelling for over half a mile, he could not say definitely, but many estates which had tried oiling found a radius of half a mile gave good results. It was not possible to lay down a hard and fast rule as to what distance anopheles travelled. In Panama experiments with painted anopheles showed that some travelled as far as 6,000 feet.

Mr. LAWFORD asked what was the safe margin around which water should be oiled?

Dr. LUCY said a great deal of enquiry was necessary before a hard-and-fast rule could be laid down. Certainly half a mile was the absolute minimum, and the further they went the better. Each case must be taken on its merits. As to the habits of mosquitoes, that was a question they knew very little about, though the anophelines preferred clear running water, and were seldom found in dirty water. It was a question which required a good deal of research, and he hoped a man would be appointed to enquire into that in the future. He had seen anophelines in the overflow from factories, but they didn't like it.

Mr. HARRISON said that he would like to know what Dr. Lucy thought about mosquito-proof lines and the leaving of ravines in blukar for the prevention of malaria.

Dr. LUCY replied that as regards mosquito-proof lines he knew of two or three estates which had attempted it. Many years ago mosquito-proof hospitals were started in Negri Sembilan. There was not the slightest doubt that it did some good, but there was another side to the question. There was immense difficulty in

keeping the wire proofing in order as coolies threw rubbish and dirt at it and very quickly destroyed its efficiency. If they could keep a set of lines mosquito-proof, there could be no doubt as to the good results.

Experience gained in the Government hospitals and the gaols where there was a large amount of supervision showed that the cells and wards only became mosquito traps. He was, therefore, doubtful whether it was a measure that could be recommended for universal adoption.

Regarding ravines being allowed to lie in blukar, that was a means of adding to their troubles above all others. Mosquitoes multiplied a thousandfold in such places, particularly in the deep depressions caused by the footfall of man and beast, and in his opinion it was the best means of propagating mosquitoes. Dr. Strickland's idea was to allow ravines to go back into virgin jungle, and that would not happen in their time.

Mr. HENDRIE said that he could not understand how six sets of lines could accommodate 500 coolies. He also asked what was the best pump in Dr. Lucy's opinion to prevent water wastage, etc. ?

Dr. LUCY replied that as regards Mr. Hendrie's remarks about line accommodation—what he meant was rooms of 12 feet by 12 feet. As regards pumps, the old British village pump was easily procurable. Its cost was between $150 and $300 but it had stood for a hundred years and was yet the best principle.

Mr. PINCHING asked whether domestic pets, such as fowls, goats, etc., were detrimental to the health of the coolies. He also asked what distance lines should be away from swamps.

Dr. LUCY said as to the breeding of fowls and live stock in the cooly lines, he thought they should be absolutely excluded. As to the distance lines should be away from swamps, he could only say as far away as possible, though swamps were less harmful than ravines with a running trickle of water.

Another member stated that as about 90 per cent. of coolies from India suffered from hook worm was it not advisable to treat them when in quarantine ?

Dr. LUCY said that with regard to the treatment of hook worm in the quarantine station, the cooly already had to undergo a bewildering series of examinations, quarantine, vaccination, quinine rationing, and many such ordeals, and whether it would be wise to add hook worm treatment was a matter of doubt. About 80 per cent. of the arrivals from India suffered from hook worm. Some coolies had housed the worm for a long time and only when coming to a malarious centre was their health seriously impaired by it. The present treatment was short, but, he thought, rather

drastic, and it would not be wise to treat the coolies for hook worm in the quarantine station, but it might be done as a routine measure after their arrival on the estates.

Dr. Day said that they had no experiments to show the real value of prophylaxis. When coolies got to hospital it was difficult to diagnose the cases. He agreed that a big hospital had advantages, such as more complete equipment, over the small hospital, but it was to be remembered that cases did not come into hospitals until they were really bad. The main question was to catch the patients early. A man who got ill would never be sent off at once to a hospital that was seven or eight miles away. He, therefore, thought that there was, after all, a good deal to be said for the small hospital.

Dr. Lucy in reply said that there was no doubt that the concensus of opinion was that where quinine prophylaxis was carried out thoroughly and systematically they not only got less malaria, but malaria was less virulent in type. He could not help thinking that quinine prophylaxis had fallen into disrepute to a great extent because quinine was not given as it should be. In nearly every case where he had gone into the question closely he found there were loopholes, a large number of coolies and dependents (including children, who were particularly dangerous) having escaped the quinine prophylaxis. As to the experiments suggested, one would like to see them carried out. But he did maintain that the concensus of opinion was in favour of continuing the quinine ration in areas of infection.

As to group hospitals, on the question of discipline Dr. Lucy did not think that an argument against them. That was a question of administration. As to coolies a distance away not being willing to go into hospital, it was not a question of coolies walking into hospital but of being sent there. That was for the manager to see to.

The Chairman (Mr. L. Lewton-Brain) concluded the proceedings by heartily thanking Dr. Lucy for his interesting paper.

Abstract of Meteorological Readings in the various Districts of the Federated Malay States for the month of March, 1917.

District.	Mean Barometrical Pressure at 32° Fah.	Maximum in Sun.	Temperature.				Hygrometer.				Prevailing Direction of Winds.	Total Rainfall.	Greatest Rainfall during 24 hours.
			Mean Dry Bulb.	Maximum.	Minimum.	Range.	Mean Wet Bulb.	Vapour Tension.	Dew Point.	Humidity.			
Kelantan, Kota Bharu	...	138.86	80.8	87.00	72.12	14.88	74.6	.744	70.4	70.	...	15.03	3.56
Pahang, Kuala Lipis	...	...	79.72	88.51	72.74	15.77	75.07	...	...	...	...	11.91	2.23
Johore, Johore Bharu	...	...	...	87.68	72.70	14.98	...	...	...	...	...	15.24	...
Singapore, Kandang Kerbau ...	29.770	166.0	81.16	86.9	74.0	12.9	76.93	.868	...	82.	...	11.37	3.05
Malacca, Durian Daun	29.862	143.1	81.7	86.1	71.7	14.4	78.5	.927	...	85.	N.E.	6.22	1.02
Negri Sembilan, Seremban ...	...	159.4	76.9	86.5	70.6	15.9	73.8	.778	71.6	84.4	N.W.	15.55	2.77
„ Kuala Pilah ...	...	139.4	80.8	89.0	71.3	17.7	78.0	.910	76.1	86.2	...	16.57	1.86
„ Port Dickson...	...	128.6	81.0	86.7	73.5	13.2	75.4	.843	74.0	79.8	...	5.72	.96
Selangor, Kuala Lumpur ...	29.761	139.0	82.7	89.7	72.8	16.9	76.0	.795	69.3	70.	N.E.	9.73	3.06
„ Klang...	...	...	78.6	84.7	72.3	12.4	75.7	...	...	...	...	11.12	1.78
„ Kuala Selangor ...	...	...	...	87.3	74.0	13.4	...	...	...	...	...	11.77	4.90
„ Rawang	...	...	...	91.1	...	...	...	...	...	...	...	14.51	4.24
Perak, Telok Anson	...	...	80.23	91.	68.	23.	76.33	.857	...	85.	...	15.31	4.09
„ Ipoh	...	...	81.02	94.	70.	24.	76.00	.831	73.53	78.	...	16.61	4.56
„ Taiping	...	114.	79.66	93.	71.	22.	76.11	.855	...	85.	...	24.52	3.58
„ The Cottage	...	...	...	...	...	...	...	...	...	...	...	41.18	6.29
„ Parit Buntar	...	...	80.61	91.	71.	20.	76.62	.866	...	85.	...	12.95	2.56
Penang, Georgetown	29.795	142.7	83.3	89.8	73.1	16.7	77.7	.871	75.2	77.	E.	4.17	1.31
Kedah, Alor Star	...	...	...	...	...	...	...	...	...	...	...	16.43	3.90
Perlis, Perlis	...	...	...	80.03	72.58	15.45	...	...	...	...	...	15.02	...